

1. An In-Circuit Emulation system breakpoint control, comprising:
  - a microcontroller;
  - a virtual microcontroller operating in lock-step synchronization with the microcontroller;
  - a breakpoint lookup table associated with the virtual microcontroller with a break bit associated with each of a plurality of instruction addresses, the break bit being set to indicate that a break is to occur at a specified instruction address; and
  - a breakpoint controller that sends a break message to the microcontroller whenever an instruction address is encountered that is associated with a set break bit.
2. The apparatus according to claim 1, wherein the break message is sent to the microcontroller over an interface linking the microcontroller with the virtual microcontroller.
3. The apparatus according to claim 1, further comprising a program counter that increments through the breakpoint lookup table as a sequence of instructions is executed.
4. The apparatus according to claim 1, further comprising a host computer that programs the breakpoint lookup table to set a breakpoint bit at an instruction address where a break is to occur.
5. The apparatus according to claim 1, wherein the microcontroller and the virtual microcontroller operate in a two phase cycle comprising a control phase and a data transfer phase.
6. The apparatus according to claim 5, wherein the break message is sent during the control phase.

- 1        7.     A method of establishing a breakpoint in a microcontroller in an In-Circuit  
2        Emulation system, comprising:  
3                storing a breakpoint lookup table in a virtual microcontroller;  
4                executing a sequence of instructions in a microcontroller and in the virtual  
5        microcontroller in lock-step synchronization;  
6                at each instruction of the sequence of instructions, inspecting the breakpoint  
7        lookup table for a set break bit associated with instruction; and  
8                if a break bit is set, sending a break message to the microcontroller to  
9        implement a break in instruction execution.
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- 11       8.     The method according to claim 7, wherein the lookup table comprises a  
12       memory having a break bit associated with each instruction address.
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- 14       9.     The method according to claim 7, further comprising programming the  
15       lookup table from a host computer.
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- 17       10.    The method according to claim 7, further comprising incrementing a program  
18       counter through the breakpoint lookup table as a sequence of instructions is  
19       executed.
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- 21       11.    The method according to claim 7, further comprising halting execution of  
22       instructions in the microcontroller and the virtual microcontroller prior to the  
23       instruction associated with the set break bit.
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- 25       12.    The method according to claim 7, wherein the microcontroller and the virtual  
26       microcontroller operate in a two phase cycle comprising a control phase and a data  
27       transfer phase.
- 28
- 29       13.    The method according to claim 12, wherein the break message is sent  
30       during the control phase.

1 14. A method of establishing a breakpoint in an In-Circuit Emulation system,  
2 comprising:

3 providing an microcontroller and a virtual microcontroller executing a  
4 sequence of instructions in lock-step synchronization, the virtual microcontroller  
5 having a breakpoint lookup table;

6 determining an instruction address which a break is to precede; and

7 programming the breakpoint lookup table to have a set break bit at the  
8 instruction address with a break is to precede.

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10 15. The method according to claim 14, further comprising at each instruction of  
11 the sequence of instructions, inspecting the breakpoint lookup table for a set break  
12 bit associated with instruction.

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14 16. The method according to claim 15, further comprising halting execution of  
15 instructions in the microcontroller and the virtual microcontroller prior to the  
16 instruction associated with the set break bit.

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18 17. The method according to claim 15, wherein if a break bit is set, sending a  
19 break message to the microcontroller to implement a break in instruction execution.

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21 18. The method according to claim 14, wherein the lookup table comprises a  
22 memory having a break bit associated with each instruction address.

23  
24 19. The method according to claim 14, wherein the programming of the lookup  
25 table is carried out from a host computer.

26  
27 20. The method according to claim 14, wherein the microcontroller and the  
28 virtual microcontroller operate in a two phase cycle comprising a control phase and  
29 a data transfer phase, and wherein the break message is sent during the control  
30 phase.